Limnimetric and Meteorological Observations in Switzerland
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4. *Limnimetric and Meteorological Observations in Switzerland.* By Professor PAUL CHAIX, Corresponding Member R.G.S.

I HAVE just sent to the Royal Geographical Society a map, under the title of General Table of the Limnimetric and Meteorological Stations in Switzerland during the Year 1871, collected by the Federal Hydrometrical Board. A careful examination of the results seems to me to point the way to a few general facts, which I beg leave to submit to your attention, with the addition of some other observations.

Those stations only have been inscribed on the Hydrographical Map of Switzerland where observations have led to important results. They are 94 in number, 39 of which belong to the mountainous regions. They seem to authorise a division into eight or nine groups, a division based *à priori*—1st, upon the geographical position; 2nd, upon the udometric results to which observations have led:—

1st. The Jurassic station, on a line from Geneva to Olten, where the average yearly fall of rain amounts to 943 millimètres for the plains, and 1313 in the mountains.

2nd. Stations on a meridian line, from Bex in the south to Friburgh in the north, all placed on a higher level than the plains of the above-mentioned group. Here the rains, brought by the western winds to a broken line of mountains of moderate height, are stopped before that curtain, and precipitated to the average amount of 1218 millimètres.

3rd. Fifteen stations scattered on the tableland of the centre of Switzerland, from Berne to Constance, where the average fall is 1000 millimètres.

4th. Twenty-five stations, central highland stations, from the Beatenberg on the south-west to Davos and St. Gall on the north-east. In that important region the average rainfall is indeed 1461 millimètres, but it is greatly surpassed on the top of the Rigi (1828 millimètres); at Linthal, at the south extremity of Glarus (2202 millimètres); and, above all, at Thusis, where the fall reaches 2755 millimètres.

5th. At the stations in Valais (not including mountain-passes) the average is reduced to 680 millimètres, and to 791 millimètres in the five stations of Engadine; which two valleys are, the one as well as the other, on a line from east by north-east to south-west by west, and equally sheltered from rainy winds from the west and from the north.

6th. On the western passes, the Great St. Bernard and the Simplon, the fall is 1030 millimètres.

7th. On the eastern passes, the Grimsel, St. Gothard, Lukmanier (La Platte), Splugen, St. Bernardin, the Julian, and the Bernina, the average is 1835 millimètres; but the amount of rain reaches 2328 at the Grimsel, and 2742 at St. Bernardin.

8th. Five stations scattered on the south side of the Alps, in the Tessin and Val Bregaglia, offer almost identically a rainfall of 1665 millimètres.

Hydrometric Measurements.—The Swiss rivers distribute their waters in four different basins or watersheds, the extent of which, on the Swiss territory, is given, together with the length of their course, in the following table:—

	Square Kilomètres.	Course in Kilomètres.
In the basin of the Rhine	35,906·65	.. .. 319·5
„ „ Rhône	7,994·51	.. .. 233·4
„ „ Tessin	6,548·09*	.. .. 70·4
„ „ Inn	1,971·30	.. .. 87·2
	52,420·55	

* 2,700 of which are out of Switzerland.

The discharge of the Rhône, at the Porte de Sex, before it enters the Lake of Geneva, is 737 cubic mètres per second when at its maximum, 58 as a minimum, and 199 upon an average. On the other extremity, where it flows out of the lake, it is given as 82 for a minimum, 270 as an average, and 418 at the highest. We cannot, however, fail to check the above numbers by many others, the result of the experience of skilful observers and of our own; 418 cubic millimètres is below the proper number, as it is below that of 424 found by General Dufour, Professor Auguste de la Rive, and Professor Daniel Colladon, who measured the discharge of the river on the 24th of September, 1840, when they were no longer at their highest level. On the other hand, Professor Plantamour and myself measured them at their very lowest ebb on the 4th of March, 1858, when the discharge was reduced to no more than 40 cubic mètres in a second, much less than the number 82 given by the Hydrometric Commission. A few days before that date, and much under the same atmospheric circumstances, M. Charles Dufour, of Morges, did not find more than a discharge of 39 cubic mètres at the Porte de Sex.

The curious but very plain fact of the maximum discharge being less at the lower end of the lake than it is where the Rhône enters it, is easily explained by the short duration of very high waters, sometimes not more than a few hours, and the spreading of those waters over the vast surface of the lake; while at the end of winter and the first weeks of the spring the lowest level is sometimes the same for weeks together.

A second proof of the happy regulating influence of our lakes on their tributary streams is found again in this fact—that the Rhine, measured at Au, in the Rheinthal, has a minimum discharge of 83 cubic mètres, an average of 191, and a maximum of 902 in a second; while at its outlet from the Lake of Constance, at Stein, the minimum being 124 cubic mètres, the average 330, the maximum does not rise above 594.

The same river, as it flows out of our territory below Basle, discharges 2997 cubic mètres per second at its maximum, 899 at their lowest ebb, and 1000 as an average. Partial measures have been made of the three streams, the Reuss, the Limmat, and the Upper Aar, before they meet, as well as their united waters in the Aar at Döttingen, at a short distance below their meeting point. The numbers thus obtained offer a striking concordance as far as the lowest and average waters are concerned, while the united streams do not, at high waters, reach the amount of the three different high-waters number:—

	Limmat.	Reuss.	Aar.	Sums.	The Aar, measured at Döttingen, below the Junction at Brugg.
Maxima ..	342	466	1028	1836	1616
Average ..	84	133	291	508	512
Minima ..	38	46	124	208	209

This is a natural result, as there is but little likelihood that the period of the highest waters should happen at the very same time in the three streams. By the same cause the discharge of the river Zihl, flowing from the Lake of Bienne, added to that of the Aar at Aarberg, makes a sum a little greater than the result of a direct measurement made below the point where they meet :—

	Maximum.	Average.	Minimum.
The Zihl discharges	191	62	28 m.
The Aar at Aarberg	673	231	95 „
Sums	864	293	123 „

	Maximum.	Average.	Minimum.
Discharge of the Rhine at Büren	869	231	95 cubic mètres.

The total discharge of all the united waters at their average level is, for—

The Rhine	1000 cubic mètres
„ Rhône	270 „
„ Tessin	401 „
„ Inn	37 „
All the collected waters of Switzerland	1708 „

distributed over a total extent of 524 square myriamètres, give, as a mean discharge for each square myriamètre, 3 m. 2 cubic mètres of water, or for each separate basin :—

The Rhine	2·8 cubic mètres per second
„ Rhône	3·4 „ „
„ Tessin	6·0 „ „
„ Inn	3·0 „ „

The variations in the level of the lakes are as follow between their highest and lowest level :—

	Extent		Discharge per Second, in Cubic Mètres			Variation of Level.
	In Hectares.	In Swiss Square Leagues.	At Lowest Level.	At Average Level.	At Highest Level.	
						Mètres.
Lago Maggiore	21,427	9·30	126	401	848	7·50
Lake of Constance ..	53,913	23·40	124	330	594	3·00
,, Lugano	5,046	2·19	11·7	30	181	2·46
,, Lucerne	11,335	4·92	32	95	311	2·50
,, Brienz	2,995	1·30	20	57	197	2·5
,, Zurich	8,778	3·81	24	61	226	2·2
,, Bienne	4,216	1·83	28	62	191	2·0
,, Geneva	57,784	25·08	82	270	418	1·7
,, Neuchâtel ..	23,961	10·40	23	52	182	1·7
,, Movat	2,741	1·19	8	17	77	1·6
,, Thun	4,792	2·08	38	99	356	1·0
,, Zug	3,848	1·67	3	8	34	0·6

Doubts may still rest, not, indeed, on the accuracy of the above-named observations, but on the possibility of drawing definite conclusions regarding Swiss meteorology from observations spread over so limited a period. The

Hydrometric Commission has not as yet been at work more than six years, and the result of their measures has not always been found in complete conformity with other positive observations, such, for instance, as mine on the Rhône. Besides, Professor E. Plantamour, himself a member of the Commission, asserts that it is very difficult completely to rely on the data of the rain-gauge in very high stations, where most of the rain falls in the shape of snow and with stormy weather.

Professor M. Alphonse Favre has already undertaken the very serious labour of sounding the Lake of Geneva at the lower extremity of its basin, where he found by two lines of soundings opposite Chambésy and opposite Genthod the depths of 40 mètres and 49 mètres respectively, which are in complete agreement with the former measures of Sir Henry Delabeche and others. I beg leave here to present a few results of the soundings, 1100 in number, of Professor Guyot and Count Henri de Pourtalés in the Lake of Neuchâtel. The length is 38,000 mètres, ending, at the lower extremity, in a shoal of 30 square kilomètres, with a depth of 20 feet only. At the head of the lake, near Yverdon, it ends with a similar shoal, with a depth of 30 feet and an extent of 3 square kilomètres only. The northern shore at the foot of the Jura has an average depth of 400 feet, 444 at most, south of Cortaillod. On the south-east shore the waves seem to have worn out at their base, and cut, as a steep wall, the hills of sandstone which form the peninsula called Vully. From the materials thus torn from the hills a third shoal has been formed, with 9 to 20 feet of water, lining the shore on a line of 32 kilomètres, called the *blanc fond* (white bottom) by the fishermen. Thus a decrease of 20 feet only in the level of the waters would bring about a reduction of about 70 square kilomètres, or almost a third part of the lake. But the most curious feature revealed by M. Guyot's soundings is the existence of a longitudinal crest, parallel with the line of deep waters on the north-west shore and the shallow waters of the south-east shore, made of a steep range of sandstone, like St. Peter's Island, in the Lake of Bienne, and where the depth does not exceed 30 feet, so that an uprising of 100 feet of the land, or the subsiding of 100 feet in the water, would completely alter the shape of the lake.

PAUL CHAIX.

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5. *Hypsometrical Observations in the Central Alpine Chain of Switzerland.* By J. M. ZIEGLER, Corresponding Member R.G.S.

THE granitic masses of Bernina and Albigna form geologically as well as topographically the eastern pendant to Mont Blanc, in the central Alpine chain. The configuration of their eastern and southern slopes was until lately very little studied. Your Corresponding Member devoted nearly eight years to this task. This led him to consult very often the topographical map of the Lombardo-Venetian Staff, a good work as far as it extends (not reaching the highest mountain parts), but even there the surveyors evinced great talent in mapping. A very great hindrance was caused by a want of sufficient data for altitudes. To fill up partly this gap I made successive measurements by the aneroid on Italian territory, taking my start from the nearest Swiss meteorological stations (Zernetz, Brusio, Castasegna, and Sils).

The following list is a selection from my numerous hypsometrical determinations, given in mètres :—